

Matter

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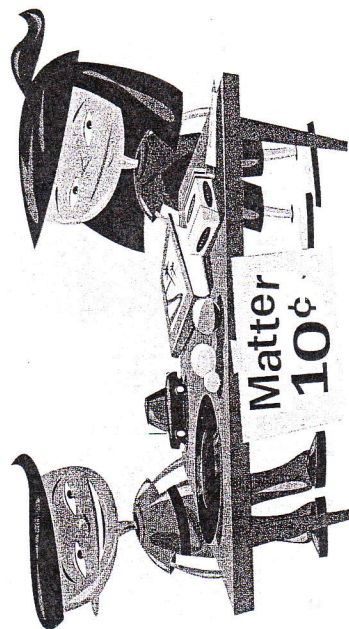
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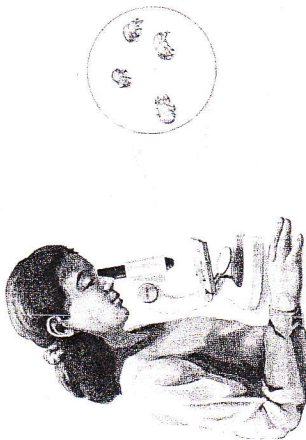
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Matter is the "stuff" that all objects and substances in the universe are made of. Because all matter takes up space (has **volume**) and contains a certain amount of material (has **mass**), all matter can be detected and measured.

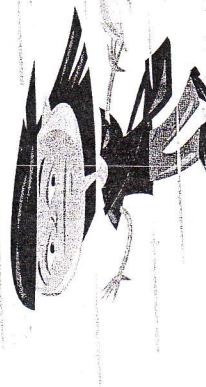


You can observe some types of matter easily with your senses. For example, you can see or feel things like rocks, trees, bicycles, and different kinds of animals. And you can see and smell things like smoke from a fire.

Other types of matter are a little more difficult to observe. The dust mites that live in your upholstered furniture and rugs are an example of matter that is too small to see with the naked eye. They can be observed only with special instruments, like a microscope.



Another example of matter that's hard to detect is air, the invisible gas that surrounds you. How do you know it's there? You can't see it or smell it, but you know it exists because you can feel it when the wind blows and see it bend the branches of trees.



What's the deal?

The word **matter** comes from the Latin word *materialis*, meaning "material" or "stuff."

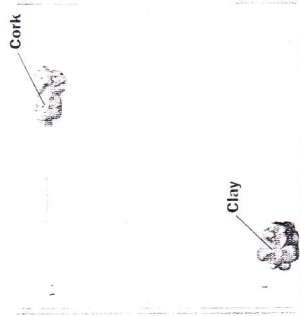
Properties of Matter

You know that a piece of cork is different from a piece of clay.

Cork will break if you squeeze it hard, but clay will flatten or bend into a new shape. If you had a scale handy, you would find that a piece of cork weighs less than a piece of clay the same size. If you dropped both objects in water, you would see that the cork floats but the clay sinks. Characteristics like these, that help us identify or classify matter, are called **properties**.

Tendency to float is a physical property of matter.

All matter has both physical properties and chemical properties. **Physical properties** are those that can be observed without changing the make-up, or identity, of the matter. For example, clay is malleable, which means it will bend or flatten when squeezed. Squeezing changes the shape of the clay but does not change what the clay is made of. Malleability is an example of a physical property. The chart below lists some common physical properties of matter.



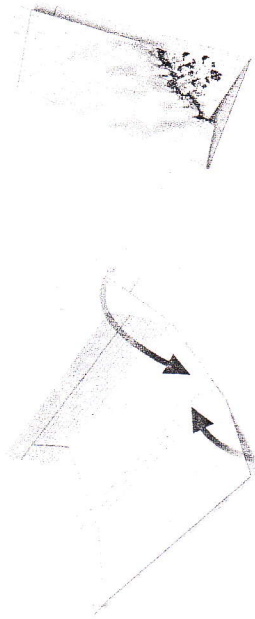
Physical Property	What It Means
Density	The amount of matter in a given volume (mass per unit volume)
Ductility	The ability to be pulled into a thin strand, like a wire
Malleability	The ability to be pressed or pounded into a thin sheet
Boiling point	The temperature at which a substance changes from a liquid to a gas
Melting point	The temperature at which a substance changes from a solid to a liquid
Electrical conductivity	How well a substance allows electricity to flow through it
Solubility	The ability to dissolve in another substance

Chemical properties describe matter based on its ability to change into a new kind of matter with different properties. For example, paper is flammable: it is capable of burning in the presence of oxygen. Flammability is a chemical property of paper. A chemical property of iron is its tendency to rust. Rusting occurs when iron reacts with oxygen to produce iron oxide. Reactivity to acid and to water are two more examples of chemical properties.

SEE
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265 Periodic
Table
269 Chemical
Reactions

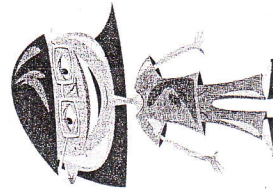
Physical and Chemical Changes

If you fold a sheet of paper into thirds, you're left with a piece of paper one-third the size of the original. But the newly folded paper is still paper. Two physical properties of the paper—its size and shape—have changed, but not its chemical properties. Such a change is called a **physical change**.



If you hold a lit match to the paper, the paper will burn. What you're left with—ash, gases, and smoke—is no longer paper. The chemical properties of the paper have changed, producing new substances. This kind of change is called a **chemical change**.

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269 Chemical
Reactions



Many physical changes can be reversed. For example, you can unfold the piece of paper to return it to its original size and shape. Most chemical changes, on the other hand, cannot easily be undone. For example, you can't "unburn" a charred piece of paper.

States of Matter

Think about the differences between, for example, a rock, milk, and air. The shape of a rock does not change unless you cut or smash it. Milk takes on the shape of its container, and if you pour it on the floor it will spread out to form a puddle. Air spreads out even more than milk does. And it keeps spreading out in all directions.

Rocks, milk, and air represent different physical forms in which a substance can exist: a rock is a **solid**, milk is a **liquid**, and air is a **gas**. Solids, liquids, and gases are three **states of matter**. The chart below lists the defining features of each state.

ouch!

The three states of matter are also known as the phases of matter.

SEE
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254 Changing States of Matter

State of Matter Defining Features

- | | |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Solid | <ul style="list-style-type: none"> • keeps its shape and volume |
| Liquid | <ul style="list-style-type: none"> • takes on the shape of its container • keeps the same volume, in a container or not • can flow |
| Gas | <ul style="list-style-type: none"> • takes on the shape and volume of its container • can flow (through a room, for example) |

Did You Know?

A fourth state of matter is called a plasma. Like a gas, a plasma does not have a definite shape or volume. Plasmas only exist at very high temperatures. Stars, including the sun, are made of matter in a plasma state.

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255 Atoms, Molecules, and Compounds

But why are solids solid, liquids liquidy, and gases gassy? To answer this question, you first need to understand three things:

- All matter is made up of tiny particles called atoms and molecules.
- These particles attract each other; the greater the attraction, the closer the particles get.
- These particles are constantly in motion and bumping into each other. The temperature of a substance is related to the speed at which its particles move.

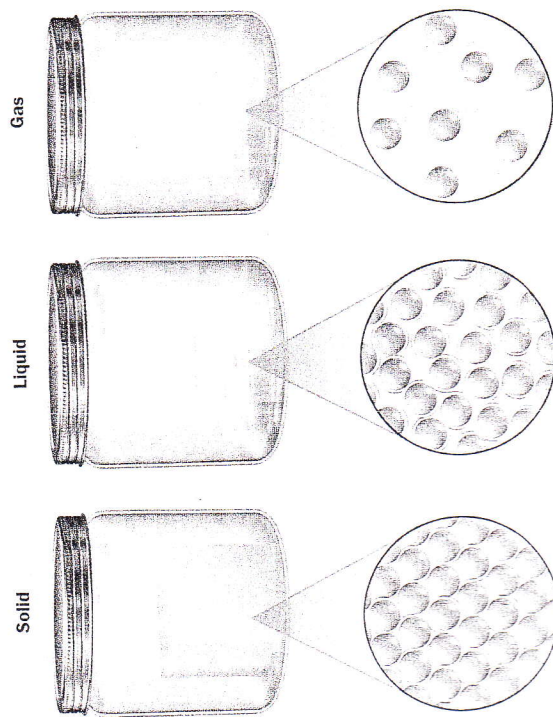
The state of a substance depends on how fast its particles move and how strong the attraction is between the particles.

Solid The particles of a substance in its solid state vibrate in place, but the vibration isn't great enough to overcome the attraction between the particles and cause them to separate. As a result, the forces between the particles cause them to lock together.

Liquid The particles of a substance move even faster when the substance is in a liquid state. As a result, the particles in a liquid can overcome some of the attraction between them. So, unlike the particles in a solid, which are locked together, the particles in a liquid can flow around and over each other. If you spill a glass of water on the floor, for example, the water molecules stick together enough to make a puddle, but not enough to keep the shape the water had when it was in the glass.

Gas The particles of a substance move fastest when the substance is in a gaseous state—so fast that they are able to overcome the attraction between them and separate from each other entirely. That's why a gas will spread out in all directions, filling up a balloon, a room, or the atmosphere.

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213 Earth's Atmosphere



Changing States of Matter

Water is a substance that can be found in three states: solid ice, liquid water, and water vapor (a gas). You know from experience that water can change from one state to another. The same is true of most other substances as well.

Melting: From Solid to Liquid

If you put an ice cube in a cup and set it on the counter, the ice will melt. **Melting** is the change from a solid state to a liquid state. The temperature at which a solid melts is called its **melting point**. The melting point of ice is 0°C.

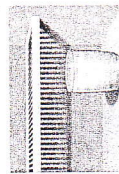


Melting

What causes a solid to melt? If you heat a solid, the particles in that solid will begin to move faster. If you keep heating the solid, eventually the motion of the particles will become great enough to overcome the attraction that locks the particles together. When that happens, the solid becomes a liquid.

Freezing: From Liquid to Solid

If you place a cup of water in the freezer, the water will turn to solid ice. **Freezing** is the change from a liquid state to a solid state. The temperature at which a liquid freezes is called its **freezing point**. Because freezing is the reverse of melting, a substance will freeze at the same temperature at which it melts. So, the freezing point of water is also 0°C.



Freezing

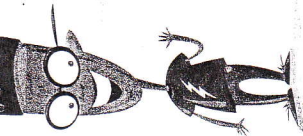
What causes a liquid to freeze? If you cool a liquid, the liquid's particles will begin to slow down. If you keep cooling the liquid, eventually the motion of the particles will slow to the point where they cannot overcome the attraction between them. At some point, the particles will lock together and the liquid becomes a solid.

Vaporization: From Liquid to Gas

If you place a pan of water on a hot stove, eventually the water will begin to boil. Water vapor (or steam) is produced during **vaporization**, the change from a liquid state to a gaseous state. Boiling causes the liquid water to vaporize. The **boiling point** of water is 100°C.



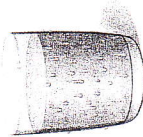
Boiling



The same process that causes a solid to melt causes a liquid to vaporize. As a substance is heated, its particles begin to move faster and faster. During vaporization, the fastest particles are able to overcome the attraction of the particles around them and break free completely. These escaped particles become a gas—water vapor.

A pan of water left on the counter top will evaporate over several days. **Evaporation** is vaporization that occurs at the surface of a liquid. Evaporation can take place at temperatures below the liquid's boiling point.

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226 Humidity and
Dew Point



Condensation

Condensation: From Gas to Liquid
Condensation is the change from a gaseous state to a liquid state. The temperature at which a gas condenses is called its **condensation point**. At sea level, the condensation point of water vapor is 100°C—the same as the boiling point of water. That is because condensation is the reverse of vaporization. Water vapor can exist in the air at temperatures below 100°C. If you pour cold juice into a glass on a humid summer day, you will begin to notice beads of water forming on the outside of the glass. What you observe is water vapor from the air around the glass that has condensed on the glass.

The same process that causes a liquid to freeze causes a vapor to condense. As a vapor cools, its particles begin to slow down. Condensation takes place when the particles slow down so much that they cannot overcome the attraction of the particles around them. When this happens, they clump together to form a liquid.

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